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INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(51) International Patent Classification 6 : C10L 1/18, 1/22 — A1

(11) International Publication Number: **WO 95/29974**

(43) International Publication Date: 9 November 1995 (09.11.95)

(21) International Application Number: PCT/US95/04981

(22) International Filing Date: 24 April 1995 (24.04.95)

(30) Priority Data: 08/236,306 — 2 May 1994 (02.05.94) — US

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(81) Designated States: AU, CA, CN, JP, KR, NZ, European patent (AT, BE, CH, DE, DK, ES, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE).

Published
With international search report.

(54) Title: FUEL ADDITIVE COMPOSITIONS CONTAINING AN ALIPHATIC AMINE, A POLYOLEFIN AND A POLY(OXYALKYLENE) MONOOL

(57) Abstract

A fuel additive composition comprising: (a) a fuel-soluble aliphatic hydrocarbyl-substituted amine having at least one basic nitrogen atom wherein the hydrocarbyl group has a number average molecular weight of about 700 to 3,000; (b) a polyolefin polymer of a C_2 to C_6 monoolefin, wherein the polymer has a number average molecular weight of about 350 to 3,000; and (c) a hydrocarbyl-terminated poly(oxyalkylene) monool having an average molecular weight of about 500 to about 5,000, wherein the oxyalkylene group is a C_2 to C_5 oxyalkylene group and the hydrocarbyl group is a C_1 to C_{30} hydrocarbyl group.

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FUEL ADDITIVE COMPOSITIONS CONTAINING AN ALIPHATIC AMINE, A POLYOLEFIN AND A POLY(OXYALKYLENE) MONOOL

BACKGROUND OF THE INVENTION

This invention relates to a fuel additive composition. More particularly, this invention relates to a fuel additive composition containing an aliphatic amine, a polyolefin and a poly(oxyalkylene) monool.

It is well known that automobile engines tend to form deposits on the surface of engine components, such as carburetor ports, throttle bodies, fuel injectors, intake ports and intake valves, due to the oxidation and polymerization of hydrocarbon fuel. These deposits, even when present in relatively minor amounts, often cause noticeable driveability problems, such as stalling and poor acceleration. Moreover, engine deposits can significantly increase an automobile's fuel consumption and production of exhaust pollutants. Therefore, the development of effective fuel detergents or "deposit control" additives to prevent or control such deposits is of considerable importance and numerous such materials are known in the art.

For example, U.S. Patent No. 3,438,757 to Honnen et al. discloses branched chain aliphatic hydrocarbon N-substituted amines and alkylene polyamines having a molecular weight in the range of about 425 to 10,000, preferably about 450 to 5,000, which are useful as detergents and dispersants in hydrocarbon liquid fuels for internal combustion engines.

U.S. Patent No. 3,502,451 to Moore et al. discloses motor fuel compositions containing a polymer or copolymer of a C_2

to C_6 unsaturated hydrocarbon or the corresponding hydrogenated polymer or copolymer, wherein the polymer or copolymer has a molecular weight in the range of about 500 to 3,500. This patent further teaches that polyolefin polymers of propylene and butylene are particularly preferred.

U.S. Patent No. 3,700,598 to Plonsker et al. discloses lubricating oil and fuel compositions containing a small amount of an N-hydrocarbyl-substituted nitrilotris ethylamine, wherein the hydrocarbyl group is preferably a polyolefin group having a molecular weight of about 300 to 20,000, preferably from 500 to 2,000. This patent further teaches that fuel compositions containing this additive will preferably also contain a small amount of a mineral oil and/or a synthetic olefin oligomer having an average molecular weight of about 300 to 2,000.

U.S. Patent No. 3,756,793 to Robinson discloses a fuel composition containing minor amounts of (A) a polyamine which is the reaction product of a halohydrocarbon having an average molecular weight between 600 to 2500 and an alkylene polyamine, and (B) an organic substance having a viscosity between 20 and 2500 cs. at 20°C. This patent further discloses that a wide variety of compounds are suitable as the organic substance, including polyamines, amides, and esters or mixtures of esters, such as aliphatic diesters of dibasic aliphatic carboxylic acids. Preferred materials for use as the organic substance are described in this patent as polymers or copolymers having an average molecular weight of 300 to 5,000 which are selected from hydrocarbons, substituted hydrocarbons containing oxygen and substituted hydrocarbons containing oxygen and nitrogen. Most preferred

polymeric compounds are described in this patent as polyalkylene oxides and polyether glycols.

U.S. Patent No. 4,173,456 to Scheule et al. discloses a fuel additive composition comprising (A) a hydrocarbon-soluble acylated poly(alkyleneamine) and (B) a normally liquid hydrocarbon-soluble polymer of a C_2 to C_6 olefin, wherein the polymer has an average molecular weight of about 400 to 3,000.

U.S. Patent No. 4,357,148 to Graiff discloses a motor fuel composition containing an octane requirement increase-inhibiting amount of (a) an oil soluble aliphatic polyamine containing at least one olefinic polymer chain and a molecular weight of about 600 to 10,000 and (b) a polymer and/or copolymer of a monoolefin having 2 to 6 carbon atoms, wherein the polymer has a number average molecular weight of about 500 to 1500.

U.S. Patent No. 4,832,702 to Kummer et al. discloses a fuel or lubricant composition containing one or more polybutyl or polyisobutylamines. This patent further discloses that, since, in fuel additives, about 50% by weight of the active substance can be replaced by polyisobutene without loss of efficiency, the addition of polyisobutene having a molecular weight of 300 to 2000, preferably from 500 to 1500, is particularly advantageous from the point of view of cost.

U.S. Patent No. 5,004,478 to Vogel et al. discloses a motor fuel for internal combustion engines which contains an additive comprising (a) an amino- or amino-containing detergent and (b) a base oil which is a mixture of (1) a polyether based on propylene oxide or butylene oxide and

having a molecular weight not less than 500, and (2) an ester of a monocarboxylic or polycarboxylic acid and an alkanol or polyol.

U.S. Patent No. 5,089,028 to Abramo et al. discloses a fuel composition containing an additive which comprises the combination of (1) a polyalkenyl succinimide, (2) a polyalkylene polymer, such as polyisobutylene or polypropylene, (3) an ester of an aliphatic or aromatic carboxylic acid, and (4) a polyether, such as polybutylene oxide, polypropylene or a polybutylene/polypropylene copolymer. The additive may also contain an optional amount of a mineral oil or a synthetic oil.

U.S. Patent No. 5,242,469 to Sakakibara et al. discloses a gasoline additive composition comprising (A) a monoester, diester or polyolester, and (B) a dispersant selected from (1) a monosuccinimide, (2) a bis-succinimide, (3) an alkylamine having a polyolefin polymer as an alkyl group and an average molecular weight of 500-5,000, and (4) a benzylamine derivative having an average molecular weight of 500-5,000. The additive composition may additionally contain a polyoxyalkylene glycol or its derivative and/or a lubricant oil fraction.

PCT International Patent Application Publication No. WO 92/15656, published September 17, 1992, discloses an additive for gasoline petroleum fuel comprising (A) an oil soluble polyolefin polyamine containing at least one olefinic polymer chain, and (B) a polymer of a C_2 to C_6 monoolefin, wherein the polymer has a number average molecular weight of up to 2,000, and preferably up to 500. This document further discloses that the additive may be

used in combination with other additives, including plasticizer esters, such as adipates and mixtures thereof, scavengers, antioxidants, ignition improvers, and metal deactivators.

European Patent Application Publication No. 0,382,159 A1, published August 16, 1990, discloses a liquid hydrocarbon fuel for an internal combustion engine containing a deposit removing and residue inhibiting amount of at least one C_1 to C_4 dialkyl ester of a C_4 to C_6 aliphatic dibasic acid.

European Patent Application Publication No. 0,356,726 A2, published March 7, 1990 discloses fuel compositions containing esters of aromatic di-, tri-, or tetra-carboxylic acids with long-chain aliphatic alcohols or ether alcohols, wherein the alcohols are produced by the hydroformylation of branched olefins, and wherein the total carbon number of the esters is at least 36 carbon atoms and the molecular weight of the esters is 550 to 1,500, preferably 600 to 1,200.

U.S. Patent No. 4,877,416 to Campbell discloses a fuel composition which contains (A) a hydrocarbyl-substituted amine or polyamine having an average molecular weight of about 750 to 10,000 and at least one basic nitrogen atom, and (B) a hydrocarbyl-terminated poly(oxyalkylene) monool having an average molecular weight of about 500 to 5,000.

It has now been discovered that the unique combination of an aliphatic hydrocarbyl-substituted amine, a polyolefin polymer and a poly(oxyalkylene) monool provides excellent control of engine deposits, especially intake valve deposits, when employed as a fuel additive composition for hydrocarbon fuels.

SUMMARY OF THE INVENTION

The present invention provides a novel fuel additive composition comprising:

(a) a fuel-soluble aliphatic hydrocarbyl-substituted amine having at least one basic nitrogen atom wherein the hydrocarbyl group has a number average molecular weight of about 700 to 3,000;

(b) a polyolefin polymer of a C_2 to C_6 monoolefin, wherein the polymer has a number average molecular weight of about 350 to 3,000; and

(c) a hydrocarbyl-terminated poly(oxyalkylene) monool having an average molecular weight of about 500 to about 5,000, wherein the oxyalkylene group is a C_2 to C_5 oxyalkylene group and the hydrocarbyl group is a C_1 to C_{30} hydrocarbyl group.

The present invention further provides a fuel composition comprising a major amount of hydrocarbons boiling in the gasoline or diesel range and an effective detergent amount of the novel fuel additive composition described above.

The present invention is also concerned with a fuel concentrate comprising an inert stable oleophilic organic solvent boiling in the range of from about 150°F to 400°F and from about 10 to 70 weight percent of the fuel additive composition of the instant invention.

Among other factors, the present invention is based on the surprising discovery that the unique combination of an

aliphatic amine, a polyolefin and a poly(oxyalkylene) monool provides unexpectedly superior deposit control performance when compared to the combination of aliphatic amine and either polyolefin or poly(oxyalkylene) monool alone.

DETAILED DESCRIPTION OF THE INVENTION

As noted above, the fuel additive composition of the present invention contains an aliphatic hydrocarbyl-substituted amine, a polyolefin polymer, and a hydrocarbyl-terminated poly(oxyalkylene) monool. These compounds are described in detail below.

A. The Aliphatic Hydrocarbyl-Substituted Amine

The fuel-soluble aliphatic hydrocarbyl-substituted amine component of the present fuel additive composition is a straight or branched chain hydrocarbyl-substituted amine having at least one basic nitrogen atom wherein the hydrocarbyl group has a number average molecular weight of about 700 to 3,000. Typically, such aliphatic amines will be of sufficient molecular weight so as to be nonvolatile at normal engine intake valve operating temperatures, which are generally in the range of about 175°C to 300°.

Preferably, the hydrocarbyl group will have a number average molecular weight in the range of about 750 to 2,200, and more preferably, in the range of about 900 to 1,500. The hydrocarbyl group will generally be branched chain.

When employing a branched-chain hydrocarbyl amine, the hydrocarbyl group is preferably derived from polymers of C_2 to C_6 olefins. Such branched-chain hydrocarbyl group will

ordinarily be prepared by polymerizing olefins of from 2 to 6 carbon atoms (ethylene being copolymerized with another olefin so as to provide a branched-chain). The branched chain hydrocarbyl group will generally have at least 1 branch per 6 carbon atoms along the chain, preferably at least 1 branch per 4 carbon atoms along the chain and, more preferably, at least 1 branch per 2 carbon atoms along the chain. The preferred branched-chain hydrocarbyl groups are polypropylene and polyisobutylene. The branches will usually be of from 1 to 2 carbon atoms, preferably 1 carbon atom, that is, methyl. In general, the branched-chain hydrocarbyl group will contain from about 18 to about 214 carbon atoms, preferably from about 50 to about 157 carbon atoms.

In most instances, the branched-chain hydrocarbyl amines are not a pure single product, but rather a mixture of compounds having an average molecular weight. Usually, the range of molecular weights will be relatively narrow and peaked near the indicated molecular weight.

The amine component of the branched-chain hydrocarbyl amines may be derived from ammonia, a monoamine or a polyamine. The monoamine or polyamine component embodies a broad class of amines having from 1 to about 12 amine nitrogen atoms and from 1 to 40 carbon atoms with a carbon to nitrogen ratio between about 1:1 and 10:1. Generally, the monoamine will contain from 1 to about 40 carbon atoms and the polyamine will contain from 2 to about 12 amine nitrogen atoms and from 2 to about 40 carbon atoms. In most instances, the amine component is not a pure single product, but rather a mixture of compounds having a major quantity of the designated amine. For the more complicated polyamines, the compositions will be a mixture of amines having as the major

product the compound indicated and having minor amounts of analogous compounds. Suitable monoamines and polyamines are described more fully below.

When the amine component is a polyamine, it will preferably be a polyalkylene polyamine, including alkylenediamine. Preferably, the alkylene group will contain from 2 to 6 carbon atoms, more preferably from 2 to 3 carbon atoms. Examples of such polyamines include ethylene diamine, diethylene triamine, triethylene tetramine and tetraethylene pentamine. Preferred polyamines are ethylene diamine and diethylene triamine.

Particularly preferred branched-chain hydrocarbyl amines include polyisobutenyl ethylene diamine and polyisobutyl amine, wherein the polyisobutyl group is substantially saturated and the amine moiety is derived from ammonia.

The aliphatic hydrocarbyl amines employed in the fuel additive composition of the invention are prepared by conventional procedures known in the art. Such aliphatic hydrocarbyl amines and their preparations are described in detail in U.S. Patent Nos. 3,438,757; 3,565,804; 3,574,576; 3,848,056; 3,960,515; and 4,832,702, the disclosures of which are incorporated herein by reference.

Typically, the hydrocarbyl-substituted amines employed in this invention are prepared by reacting a hydrocarbyl halide, such as a hydrocarbyl chloride, with ammonia or a primary or secondary amine to produce the hydrocarbyl-substituted amine.

As noted above, the amine component of the presently employed hydrocarbyl-substituted amine is derived from a

nitrogen-containing compound selected from ammonia, a monoamine having from 1 to 40 carbon atoms, and a polyamine having from 2 to about 12 amine nitrogen atoms and from 2 to about 40 carbon atoms. The nitrogen-containing compound is reacted with a hydrocarbyl halide to produce the hydrocarbyl-substituted amine fuel additive finding use within the scope of the present invention. The amine component provides a hydrocarbyl amine reaction product with, on average, at least about one basic nitrogen atom per product molecule, i.e., a nitrogen atom titratable by a strong acid.

Preferably, the amine component is derived from a polyamine having from 2 to about 12 amine nitrogen atoms and from 2 to about 40 carbon atoms. The polyamine preferably has a carbon-to-nitrogen ratio of from about 1:1 to 10:1.

The polyamine may be substituted with substituents selected from (A) hydrogen, (B) hydrocarbyl groups of from 1 to about 10 carbon atoms, (C) acyl groups of from 2 to about 10 carbon atoms, and (D) monoketo, monohydroxy, mononitro, monocyano, lower alkyl and lower alkoxy derivatives of (B) and (C). "Lower", as used in terms like lower alkyl or lower alkoxy, means a group containing from 1 to about 6 carbon atoms. At least one of the substituents on one of the basic nitrogen atoms of the polyamine is hydrogen, e.g., at least one of the basic nitrogen atoms of the polyamine is a primary or secondary amino nitrogen.

Hydrocarbyl, as used in describing the polyamine moiety on the aliphatic amine employed in this invention, denotes an organic radical composed of carbon and hydrogen which may be aliphatic, alicyclic, aromatic or combinations thereof, e.g., aralkyl. Preferably, the hydrocarbyl group will be

relatively free of aliphatic unsaturation, i.e., ethylenic and acetylenic, particularly acetylenic unsaturation. The substituted polyamines of the present invention are generally, but not necessarily, N-substituted polyamines. Exemplary hydrocarbyl groups and substituted hydrocarbyl groups include alkyls such as methyl, ethyl, propyl, butyl, isobutyl, pentyl, hexyl, octyl, etc., alkenyls such as propenyl, isobutenyl, hexenyl, octenyl, etc., hydroxyalkyls, such as 2-hydroxyethyl, 3-hydroxypropyl, hydroxy-isopropyl, 4-hydroxybutyl, etc., ketoalkyls, such as 2-ketopropyl, 6-ketooctyl, etc., alkoxy and lower alkenoxy alkyls, such as ethoxyethyl, ethoxypropyl, propoxyethyl, propoxypropyl, diethyleneoxymethyl, triethyleneoxyethyl, tetraethyleneoxyethyl, diethyleneoxyhexyl, etc. The aforementioned acyl groups (C) are such as propionyl, acetyl, etc. The more preferred substituents are hydrogen, C_1-C_6 alkyls and C_1-C_6 hydroxyalkyls.

In a substituted polyamine, the substituents are found at any atom capable of receiving them. The substituted atoms, e.g., substituted nitrogen atoms, are generally geometrically unequivalent, and consequently the substituted amines finding use in the present invention can be mixtures of mono- and poly-substituted polyamines with substituent groups situated at equivalent and/or unequivalent atoms.

The more preferred polyamine finding use within the scope of the present invention is a polyalkylene polyamine, including alkylene diamine, and including substituted polyamines, e.g., alkyl and hydroxyalkyl-substituted polyalkylene polyamine. Preferably, the alkylene group contains from 2 to 6 carbon atoms, there being preferably from 2 to 3 carbon atoms between the nitrogen atoms. Such groups are

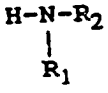
exemplified by ethylene, 1,2-propylene, 2,2-dimethyl-propylene, trimethylene, 1,3,2-hydroxypropylene, etc. Examples of such polyamines include ethylene diamine, diethylene triamine, di(trimethylene) triamine, dipropylene triamine, triethylene tetraamine, tripropylene tetraamine, tetraethylene pentamine, and pentaethylene hexamine. Such amines encompass isomers such as branched-chain polyamines and previously-mentioned substituted polyamines, including hydroxy- and hydrocarbyl-substituted polyamines. Among the polyalkylene polyamines, those containing 2-12 amino nitrogen atoms and 2-24 carbon atoms are especially preferred, and the C_2-C_3 alkylene polyamines are most preferred, that is, ethylene diamine, polyethylene polyamine, propylene diamine and polypropylene polyamine, and in particular, the lower polyalkylene polyamines, e.g., ethylene diamine, dipropylene triamine, etc. Particularly preferred polyalkylene polyamines are ethylene diamine and diethylene triamine.

The amine component of the presently employed aliphatic amine fuel additive also may be derived from heterocyclic polyamines, heterocyclic substituted amines and substituted heterocyclic compounds, wherein the heterocycle comprises one or more 5-6 membered rings containing oxygen and/or nitrogen. Such heterocyclic rings may be saturated or unsaturated and substituted with groups selected from the aforementioned (A), (B), (C) and (D). The heterocyclic compounds are exemplified by piperazines, such as 2-methylpiperazine, N-(2-hydroxyethyl)-piperazine, 1,2-bis-(N-piperazinyl)ethane and N,N'-bis(N-piperazinyl)piperazine, 2-methylimidazoline, 3-aminopiperidine, 3-aminopyridine, N-(3-aminopropyl)-

morpholine, etc. Among the heterocyclic compounds, the piperazines are preferred.

Typical polyamines that can be used to form the aliphatic amine additives employed in this invention by reaction with a hydrocarbyl halide include the following: ethylene diamine, 1,2-propylene diamine, 1,3-propylene diamine, diethylene triamine, triethylene tetramine, hexamethylene diamine, tetraethylene pentamine, dimethylaminopropylene diamine, N-(beta-aminoethyl)piperazine, N-(beta-aminoethyl)piperidine, 3-amino-N-ethylpiperidine, N-(beta-aminoethyl) morpholine, N,N'-di(beta-aminoethyl)piperazine, N,N'-di(beta-aminoethyl)imidazolidone-2, N-(beta-cyanoethyl) ethane-1,2-diamine, 1-amino-3,6,9-triazaoctadecane, 1-amino-3,6-diaza-9-oxadecane, N-(beta-aminoethyl) diethanolamine, N'acetylmethyl-N-(beta-aminoethyl) ethane-1,2-diamine, N-acetonyl-1,2-propanediamine, N-(beta-nitroethyl)-1,3-propane diamine, 1,3-dimethyl-5(beta-aminoethyl)hexahydrotriazine, N-(beta-aminoethyl)-hexahydrotriazine, 5-(beta-aminoethyl)-1,3,5-dioxazine, 2-(2-aminoethylamino)ethanol, and 2-[2-(2-aminoethylamino) ethylamino]ethanol.

Alternatively, the amine component of the presently employed aliphatic hydrocarbyl-substituted amine may be derived from an amine having the formula:



wherein R_1 and R_2 are independently selected from the group consisting of hydrogen and hydrocarbyl of 1 to about 20 carbon atoms and, when taken together, R_1 and R_2 may form

one or more 5- or 6-membered rings containing up to about 20 carbon atoms. Preferably, R_1 is hydrogen and R_2 is a hydrocarbyl group having 1 to about 10 carbon atoms. More preferably, R_1 and R_2 are hydrogen. The hydrocarbyl groups may be straight-chain or branched and may be aliphatic, alicyclic, aromatic or combinations thereof. The hydrocarbyl groups may also contain one or more oxygen atoms.

An amine of the above formula is defined as a "secondary amine" when both R_1 and R_2 are hydrocarbyl. When R_1 is hydrogen and R_2 is hydrocarbyl, the amine is defined as a "primary amine"; and when both R_1 and R_2 are hydrogen, the amine is ammonia.

Primary amines useful in preparing the aliphatic hydrocarbyl-substituted amine fuel additives of the present invention contain 1 nitrogen atom and 1 to about 20 carbon atoms, preferably 1 to 10 carbon atoms. The primary amine may also contain one or more oxygen atoms.

Preferably, the hydrocarbyl group of the primary amine is methyl, ethyl, propyl, butyl, pentyl, hexyl, octyl, 2-hydroxyethyl or 2-methoxyethyl. More preferably, the hydrocarbyl group is methyl, ethyl or propyl.

Typical primary amines are exemplified by N-methylamine, N-ethylamine, N-n-propylamine, N-isopropylamine, N-n-butylamine, N-isobutylamine, N-sec-butylamine, N-tert-butylamine, N-n-pentylamine, N-cyclopentylamine, N-n-hexylamine, N-cyclohexylamine, N-octylamine, N-decylamine, N-dodecylamine, N-octadecylamine, N-benzylamine, N-(2-phenylethyl)amine, 2-aminoethanol,

3-amino-1-proponal, 2-(2-aminoethoxy)ethanol, N-(2-methoxyethyl)amine, N-(2-ethoxyethyl)amine, and the like. Preferred primary amines are N-methylamine, N-ethylamine and N-n-propylamine.

The amine component of the presently employed aliphatic hydrocarbyl-substituted amine fuel additive may also be derived from a secondary amine. The hydrocarbyl groups of the secondary amine may be the same or different and will generally contain 1 to about 20 carbon atoms, preferably 1 to about 10 carbon atoms. One or both of the hydrocarbyl groups may also contain one or more oxygen atoms.

Preferably, the hydrocarbyl groups of the secondary amine are independently selected from the group consisting of methyl, ethyl, propyl, butyl, pentyl, hexyl, 2-hydroxyethyl and 2-methoxyethyl. More preferably, the hydrocarbyl groups are methyl, ethyl or propyl.

Typical secondary amines which may be used in this invention include N,N-dimethylamine, N,N-diethylamine, N,N-di-n-propylamine, N,N-diisopropylamine, N,N-di-n-butylamine, N,N-di-sec-butylamine, N,N-di-n-pentylamine, N,N-di-n-hexylamine, N,N-dicyclohexylamine, N,N-dioctylamine, N-ethyl-N-methylamine, N-methyl-N-n-propylamine, N-n-butyl-N-methylamine, N-methyl-N-octylamine, N-ethyl-N-isopropylamine, N-ethyl-N-octylamine, N,N-di(2-hydrcxyethyl)amine, N,N-di(3-hydroxypropyl)amine, N,N-di(ethoxyethyl)amine, N,N-di(propoxyethyl)amine, and the like. Preferred secondary amines are N,N-dimethylamine, N,N-diethylamine and N,N-di-n-propylamine.

Cyclic secondary amines may also be employed to form the aliphatic amine additives of this invention. In such cyclic

compounds, R_1 and R_2 of the formula hereinabove, when taken together, form one or more 5- or 6-membered rings containing up to about 20 carbon atoms. The ring containing the amine nitrogen atom is generally saturated, but may be fused to one or more saturated or unsaturated rings. The rings may be substituted with hydrocarbyl groups of from 1 to about 10 carbon atoms and may contain one or more oxygen atoms.

Suitable cyclic secondary amines include piperidine, 4-methylpiperidine, pyrrolidine, morpholine, 2,6-dimethylmorpholine, and the like.

In many instances, the amine component is not a single compound but a mixture in which one or several compounds predominate with the average composition indicated. For example, tetraethylene pentamine prepared by the polymerization of aziridine or the reaction of dichloroethylene and ammonia will have both lower and higher amine members, e.g., triethylene tetraamine, substituted piperazines and pentaethylene hexamine, but the composition will be mainly tetraethylene pentamine and the empirical formula of the total amine composition will closely approximate that of tetraethylene pentamine. Finally, in preparing the compounds of this invention using a polyamine, where the various nitrogen atoms of the polyamine are not geometrically equivalent, several substitutional isomers are possible and are encompassed within the final product. Methods of preparation of amines and their reactions are detailed in Sidgewick's "The Organic Chemistry of Nitrogen", Clarendon Press, Oxford, 1966; Noller's "Chemistry of Organic Compounds", Saunders, Philadelphia, 2nd Ed., 1957; and Kirk-Othmer's "Encyclopedia of Chemical Technology", 2nd Ed., especially Volume 2, pp. 99-116.

Preferred aliphatic hydrocarbyl-substituted amines suitable for use in the present invention are hydrocarbyl-substituted polyalkylene polyamines having the formula:

$$R_3NH(R_4-NH)_nH$$

wherein R_3 is a hydrocarbyl group having a number average molecular weight of about 700 to 3,000; R_4 is alkylene of from 2 to 6 carbon atoms; and n is an integer of from 0 to about 10.

Preferably, R_3 is a hydrocarbyl group having a number average molecular weight of about 750 to 2,200, more preferably, from about 900 to 1,500. Preferably, R_4 is alkylene of from 2 to 3 carbon atoms and n is preferably an integer of from 1 to 6.

B. The Polyolefin Polymer

The polyolefin polymer component of the present fuel additive composition is a polyolefin polymer of a C_2 to C_6 monoolefin, wherein the polyolefin polymer has a number average molecular weight of about 350 to 3,000. The polyolefin polymer may be a homopolymer or a copolymer. Block copolymers are also suitable for use in this invention.

In general, the polyolefin polymer will have a number average molecular weight of about 350 to 3,000, preferably about 350 to 1,500, and more preferably from about 350 to 500. Particularly preferred polyolefin polymers will have a number average molecular weight of about 375 to 450.

The polyolefin polymers employed in the present invention are generally polyolefins which are polymers or copolymers of mono-olefins, particularly 1-mono-olefins, such as ethylene, propylene, butylene, and the like. Preferably, the mono-olefin employed will have 2 to about 4 carbon atoms, and more preferably, about 3 to 4 carbon atoms. More preferred mono-olefins include propylene and butylene, particularly isobutylene. Polyolefins prepared from such mono-olefins include polypropylene and polybutene, especially polyisobutene.

The polyisobutenes which are suitable for use in the present invention include polyisobutenes which comprise at least about 20% of the more reactive methylvinylidene isomer, preferably at least 50% and more preferably at least 70%. Suitable polyisobutenes include those prepared using BF_3 catalysts. The preparation of such polyisobutenes in which the methylvinylidene isomer comprises a high percentage of the total composition is described in U.S. Patent Nos. 4,152,499 and 4,605,808.

Examples of suitable polyisobutenes having a high alkylvinylidene content include Ultravis 30, a polyisobutene having a number average molecular weight of about 1300 and a methylvinylidene content of about 74%, and Ultravis 10, a 950 molecular weight polyisobutene having a methylvinylidene content of about 76%, both available from British Petroleum.

Preferred polyisobutenes include those having a number average molecular weight of about 375 to 450, such as Parapol 450, a polyisobutene having a number average molecular weight of about 420, available from Exxon Chemical Company.

C. The Hydrocarbyl-Terminated Poly(oxyalkylene) Monool

The hydrocarbyl-terminated poly(oxyalkylene) polymers employed in the present invention are monohydroxy compounds, i.e., alcohols, often termed monohydroxy polyethers, or polyalkylene glycol monohydrocarbylethers, or "capped" poly(oxyalkylene) glycols and are to be distinguished from the poly(oxyalkylene) glycols (diols), or polyols, which are not hydrocarbyl-terminated, i.e., not capped. The hydrocarbyl-terminated poly(oxyalkylene) alcohols are produced by the addition of lower alkylene oxides, such as ethylene oxide, propylene oxide, the butylene oxides, or the pentylene oxides to the hydroxy compound R_5OH under polymerization conditions, wherein R_5 is the hydrocarbyl group which caps the poly(oxyalkylene) chain. Methods of production and properties of these polymers are disclosed in U.S. Patent Nos. 2,841,479 and 2,782,240 and Kirk-Othmer's "Encyclopedia of Chemical Technology", 2nd Ed., Volume 19, p. 507. In the polymerization reaction, a single type of alkylene oxide may be employed, e.g., propylene oxide, in which case the product is a homopolymer, e.g., a poly(oxyalkylene) propanol. However, copolymers are equally satisfactory and random copolymers are readily prepared by contacting the hydroxyl-containing compound with a mixture of alkylene oxides, such as a mixture of propylene and butylene oxides. Block copolymers of oxyalkylene units also provide satisfactory poly(oxyalkylene) polymers for the practice of the present invention. Random polymers are more easily prepared when the reactivities of the oxides are relatively equal. In certain cases, when ethylene oxide is copolymerized with other oxides, the higher reaction rate of ethylene oxide makes the preparation of random copolymers difficult. In either case, block copolymers can be

prepared. Block copolymers are prepared by contacting the hydroxyl-containing compound with first one alkylene oxide, then the others in any order, or repetitively, under polymerization conditions. A particular block copolymer is represented by a polymer prepared by polymerizing propylene oxide on a suitable monohydroxy compound to form a poly(oxypropylene) alcohol and then polymerizing butylene oxide on the poly(oxyalkylene) alcohol.

In general, the poly(oxyalkylene) polymers are mixtures of compounds that differ in polymer chain length. However, their properties closely approximate those of the polymer represented by the average composition and molecular weight.

The polyethers employed in this invention can be represented by the formula:

$$R_5O(R_6O)_pH$$

wherein R_5 is a hydrocarbyl group of from 1 to 30 carbon atoms; R_6 is a C_2 to C_5 alkylene group; and p is an integer such that the molecular weight of the polyether is from about 500 to about 5,000.

Preferably, R_6 is a C_3 or C_4 alkylene group.

Preferably, R_5 is a C_7-C_{30} alkylphenyl group. Most preferably, R_5 is dodecylphenyl.

Preferably, the polyether has a molecular weight of from about 750 to about 3,000; and more preferably from about 900 to about 1,500.

Fuel Compositions

The fuel additive composition of the present invention will generally be employed in a hydrocarbon distillate fuel boiling in the gasoline or diesel range. The proper concentration of this additive composition necessary in order to achieve the desired detergency and dispersancy varies depending upon the type of fuel employed, the presence of other detergents, dispersants and other additives, etc. Generally, however, from 150 to 7500 weight ppm, preferably from 300 to 2500 ppm, of the present additive composition per part of base fuel is needed to achieve the best results.

In terms of individual components, fuel compositions containing the additive compositions of the invention will generally contain about 50 to 500 ppm by weight of the aliphatic amine, about 50 to 1,000 ppm by weight of the polyolefin, and about 50 to 1,000 ppm by weight of the poly(oxyalkylene) monool. The ratio of aliphatic amine to polyolefin to poly(oxyalkylene) monool (amine:polyolefin:monool) will generally be in the range of about 1 : 0.5 to 10 : 0.5 to 10, preferably about 1 : 1 to 5 : 1 to 5, and more preferably about 1:1:1.

The deposit control fuel additive composition may be formulated as a concentrate, using an inert stable oleophilic (i.e., dissolves in gasoline) organic solvent boiling in the range of about 150°F to 400°F (about 65°C to 205°C). Preferably, an aliphatic or an aromatic hydrocarbon solvent is used, such as benzene, toluene, xylene or higher-boiling aromatics or aromatic thinners. Aliphatic alcohols of about 3 to 8 carbon atoms, such as isopropanol, isobutylcarbinol, n-butanol and the like, in combination

with hydrocarbon solvents are also suitable for use with the detergent-dispersant additive. In the concentrate, the amount of the present additive composition will be ordinarily at least 10% by weight and generally not exceed 90% by weight, preferably 40 to 85 weight percent and most preferably from 50 to 80 weight percent.

In gasoline fuels, other fuel additives may be employed with the additives of the present invention, including, for example, oxygenates, such as t-butyl methyl ether, antiknock agents, such as methylcyclopentadienyl manganese tricarbonyl, and other dispersants/detergents, such as various hydrocarbyl amines, hydrocarbyl poly(oxyalkylene) amines, or succinimides. Also included may be lead scavengers, such as aryl halides, e.g., dichlorobenzene, or alkyl halides, e.g., ethylene dibromide. Additionally, antioxidants, metal deactivators, pour point depressants, corrosion inhibitors and demulsifiers may be present. The gasoline fuels may also contain amounts of other fuels such as, for example, methanol.

Additional fuel additives which may be present include fuel injector inhibitors, low molecular weight fuel injector detergents, and carburetor detergents, such as a low molecular weight hydrocarbyl amine, including polyamines, having a molecular weight below 700, such as oleyl amine or a low molecular weight polyisobutenyl ethylene diamine, for example, where the polyisobutenyl group has a number average molecular weight of about 420.

In diesel fuels, other well-known additives can be employed, such as pour point depressants, flow improverse, cetane improvers, and the like. The diesel fuels can also include other fuels such as, for example, methanol.

A fuel-soluble, nonvolatile carrier fluid or oil may also be used with the fuel additive composition of this invention. The carrier fluid is a chemically inert hydrocarbon-soluble liquid vehicle which substantially increases the nonvolatile residue (NVR), or solvent-free liquid fraction of the fuel additive composition while not overwhelmingly contributing to octane requirement increase. The carrier fluid may be a natural or synthetic oil, such as mineral oil or refined petroleum oils.

These carrier fluids are believed to act as a carrier for the fuel additives of the present invention and to assist in removing and retarding deposits. The carrier fluid may also exhibit synergistic deposit control properties when used in combination with a fuel additive composition of this invention.

The carrier fluids are typically employed in amounts ranging from about 50 to about 2000 ppm by weight of the hydrocarbon fuel, preferably from 100 to 800 ppm of the fuel. Preferably, the ratio of carrier fluid to deposit control additive will range from about 0.5:1 to about 10:1, more preferably from 1:1 to 4:1.

When employed in a fuel concentrate, carrier fluids will generally be present in amounts ranging from about 10 to about 60 weight percent, preferably from 20 to 40 weight percent.

The following examples are presented to illustrate specific embodiments of this invention and are not to be construed in any way as limiting the scope of the invention.

EXAMPLES

Example A1

An engine test was carried out using commercial regular unleaded gasoline to measure deposits on intake valves and combustion chambers using this fuel. The test engine was a 2.3 liter, Port Fuel Injected (PFI), dual spark plug, four-cylinder engine manufactured by Ford Motor Company. Major dimensions are set forth in Table 1.

Table 1
Engine Dimensions

Bore	96 mm
Stroke	79.3 mm
Displacement	2.3 liter
Compression Ratio	10.3 : 1

The test engine was operated for 100 hours (24 hours a day) on a prescribed load and speed schedule specified by the Coordinating Research Council as a standard condition for Intake Valve Deposit testing. The cycle for engine operation is set forth in Table 2.

Table 2
Engine Operating Cycle

Step	Mode	Time in Mode [minute][1]	Engine Speed [RPM]	Manifold Pressure [mm Hg Abs.]
1	Idle	4.5	2000	223
2	Load	8.5	2800	522

[1]Each step includes a 30-second transition ramp.

At the end of each test run, the intake valves were removed, washed with hexane, and weighed. The previously determined weights of the clean valves were subtracted from the weights of the valves at the end of the run. The difference between the two weights is the weight of the intake valve deposit (IVD). Also, for each cylinder, the piston top and the mating surface of the cylinder head were scraped and the deposit removed was weighed as the measure of the combustion chamber deposit (CCD). The results are set forth in Table 3 below.

Example A2

A sample fuel composition A2 was prepared by adding:

(1) 125 ppm by weight of a dodecylphenyl-terminated poly(oxybutylene) monool having an average molecular weight of about 1500, and

(2) 125 ppma (parts per million actives) by weight of a hydrocarbyl amine having a 1300 MW polyisobutenyl moiety and an ethylene diamine moiety

to the gasoline of Example A1.

The same experiment as in Example A1 was carried out using this fuel composition, and the results are shown in Table 3 below.

Example A3

A sample fuel composition A3 was prepared by adding:

(1) 125 ppm by weight of 420 number average molecular weight polyisobutene, and

(2) 125 ppma by weight of a hydrocarbyl amine having a 1300 MW polyisobutenyl moiety and an ethylene diamine moiety

to the gasoline of Example A1.

The same experiment as in Example A1 was carried out using this fuel composition, and the results are shown in Table 3 below.

Example A4

A sample fuel composition A4 was prepared by adding:

(1) 125 ppm by weight of 420 number average molecular weight polyisobutene; and

(2) 125 ppm by weight of a dodecylphenyl-terminated poly(oxybutylene) monool having an average molecular weight of about 1500, and

(3) 125 ppma by weight of a hydrocarbyl amine having a 1300 MW polyisobutenyl moiety and an ethylene diamine moiety

to the gasoline of Example A1.

The same experiment as in Example A1 was carried out using this fuel composition, and the results are shown in Table 3 below.

Table 3

Ford 2.3 Liter Engine Test Results

Test Fuel Detergent Package	Average Weight per Cylinder	
	IVD (mg)	CCD (mg)
Base Fuel A1	419	949
Fuel Composition A2	147	1278
Fuel Composition A3	580	1201
Fuel Composition A4	78	1190

The results in Table 3 show that the fuel additive composition of the present invention (Example A4) exhibits markedly improved intake valve deposit control performance, when compared to the two-component additive compositions of Examples A2 and A3, while maintaining a low level of combustion chamber deposits.

Example B

Fuel additive compositions of the present invention are also prepared which contain:

(1) 125 ppm by weight of 420 number average molecular weight polyisobutene;

(2) 125 ppm by weight of a dodecylphenyl-terminated poly(oxybutylene) monool having an average molecular weight of about 1500;

(3) 125 ppma by weight of a hydrocarbyl amine having a 1300 MW polyisobutenyl moiety and an ethylene diamine moiety;

and at least one of the following components:

(4) 125-250 ppm of a mineral oil carrier fluid; and/or

(5) 10-50 ppm, preferably 20 ppm, of a low molecular weight hydrocarbyl amine carburetor or injector detergent, such as oleyl amine or polyisobutenyl (420 MW) ethylene diamine.

WHAT IS CLAIMED IS:

1. A fuel additive composition comprising:

(a) a fuel-soluble aliphatic hydrocarbyl-substituted amine having at least one basic nitrogen atom wherein the hydrocarbyl group has a number average molecular weight of about 700 to 3,000;

(b) a polyolefin polymer of a C_2 to C_6 monoolefin, wherein the polymer has a number average molecular weight of about 350 to 3,000; and

(c) a hydrocarbyl-terminated poly(oxyalkylene) monool having an average molecular weight of about 500 to about 5,000, wherein the oxyalkylene group is a C_2 to C_5 oxyalkylene group and the hydrocarbyl group is a C_1 to C_{30} hydrocarbyl group.

2. The fuel additive composition according to Claim 1, wherein the hydrocarbyl substituent on the aliphatic amine of component (a) has a number average molecular weight of about 750 to 2,200.

3. The fuel additive composition according to Claim 2, wherein the hydrocarbyl substituent on the aliphatic amine of component (a) has a number average molecular weight of about 900 to 1,500.

4. The fuel additive composition according to Claim 1, wherein the aliphatic amine of component (a) is a branched chain hydrocarbyl-substituted amine.

5. The fuel additive composition according to Claim 4, wherein the aliphatic amine of component (a) is a polyisobutenyl amine.

6. The fuel additive composition according to Claim 4, wherein the amine moiety of the aliphatic amine is derived from a polyamine having from 2 to 12 amine nitrogen atoms and from 2 to 40 carbon atoms.

7. The fuel additive composition according to Claim 6, wherein the polyamine is a polyalkylene polyamine having 2 to 12 amine nitrogen atoms and 2 to 24 carbon atoms.

8. The fuel additive composition according to Claim 7, wherein the polyalkylene polyamine is selected from the group consisting of ethylene diamine, diethylene triamine, triethylene tetramine and tetraethylene pentamine.

9. The fuel additive composition according to Claim 8, wherein the polyalkylene polyamine is ethylene diamine or diethylene triamine.

10. The fuel additive composition according to Claim 9, wherein the aliphatic amine of component (a) is a polyisobutenyl ethylene diamine.

11. The fuel additive composition according to Claim 1, wherein the polyolefin polymer of component (b) is a polymer of a C_2 to C_4 monoolefin.

12. The fuel additive composition according to Claim 11, wherein the polyolefin polymer of component (b) is polypropylene or polybutene.

13. The fuel additive composition according to Claim 12, wherein the polyolefin polymer of component (b) is polyisobutene.

14. The fuel additive composition according to Claim 1, wherein the polyolefin polymer of component (b) has a number average molecular weight of about 350 to 1500.

15. The fuel additive composition according to Claim 14, wherein the polyolefin polymer of component (b) has a number average molecular weight of about 350 to 500.

16. The fuel additive composition according to Claim 1, wherein the hydrocarbyl-terminated poly(oxyalkylene) monool of component (c) has an average molecular weight of about 900 to 1500.

17. The fuel additive composition according to Claim 1, wherein the oxyalkylene group of the hydrocarbyl-terminated poly(oxyalkylene) monool of component (c) is a C_3 to C_4 oxyalkylene group.

18. The fuel additive composition according to Claim 17, wherein the oxyalkylene group of the hydrocarbyl-terminated poly(oxyalkylene) monool of component (c) is a C_3 oxypropylene group.

19. The fuel additive composition according to Claim 17, wherein the oxyalkylene group of the hydrocarbyl-terminated poly(oxyalkylene) monool of component (c) is a C_4 oxybutylene group.

20. The fuel additive composition according to Claim 1, wherein the hydrocarbyl group of the hydrocarbyl-terminated poly(oxyalkylene) monool of component (c) is a C_7 to C_{30} alkylphenyl group.

21. The fuel additive composition according to Claim 1, wherein component (a) is a polyisobutenyl amine, wherein the amine moiety is derived from ethylene diamine or diethylene triamine, component (b) is polyisobutene, and component (c) is a C_7 to C_{30} alkylphenyl-terminated poly(oxybutylene) monool.

22. A fuel composition comprising a major amount of hydrocarbons boiling in the gasoline or diesel range and an effective detergent amount of an additive composition comprising:

(a) a fuel-soluble aliphatic hydrocarbyl-substituted amine having at least one basic nitrogen atom wherein the hydrocarbyl group has a number average molecular weight of about 700 to 3,000;

(b) a polyolefin polymer of a C_2 to C_6 monoolefin, wherein the polymer has a number average molecular weight of about 350 to 3,000; and

(c) a hydrocarbyl-terminated poly(oxyalkylene) monool having an average molecular weight of about 500 to

about 5,000, wherein the oxyalkylene group is a C_2 to C_5 oxyalkylene group and the hydrocarbyl group is a C_1 to C_{30} hydrocarbyl group.

23. The fuel composition according to Claim 22, wherein the hydrocarbyl substituent on the aliphatic amine of component (a) has a number average molecular weight of about 750 to 2,200.

24. The fuel composition according to Claim 23, wherein the hydrocarbyl substituent on the aliphatic amine of component (a) has a number average molecular weight of about 900 to 1,500.

25. The fuel composition according to Claim 22, wherein the aliphatic amine of component (a) is a branched chain hydrocarbyl-substituted amine.

26. The fuel composition according to Claim 25, wherein the aliphatic amine of component (a) is a polyisobutenyl amine.

27. The fuel composition according to Claim 25, wherein the amine moiety of the aliphatic amine is derived from a polyamine having from 2 to 12 amine nitrogen atoms and from 2 to 40 carbon atoms.

28. The fuel composition according to Claim 27, wherein the polyamine is a polyalkylene polyamine having 2 to 12 amine nitrogen atoms and 2 to 24 carbon atoms.

29. The fuel composition according to Claim 28, wherein the polyalkylene polyamine is selected from the group consisting of ethylene diamine, diethylene triamine, triethylene tetramine and tetraethylene pentamine.

30. The fuel composition according to Claim 29, wherein the polyalkylene polyamine is ethylene diamine or diethylene triamine.

31. The fuel composition according to Claim 30, wherein the aliphatic amine of component (a) is a polyisobutenyl ethylene diamine.

32. The fuel composition according to Claim 22, wherein the polyolefin polymer of component (b) is a polymer of a C_2 to C_4 monoolefin.

33. The fuel composition according to Claim 32, wherein the polyolefin polymer of component (b) is polypropylene or polybutene.

34. The fuel composition according to Claim 33, wherein the polyolefin polymer of component (b) is polyisobutene.

35. The fuel composition according to Claim 22, wherein the polyolefin polymer of component (b) has a number average molecular weight of about 350 to 1500.

36. The fuel composition according to Claim 35, wherein the polyolefin polymer of component (b) has a number average molecular weight of about 350 to 500.

37. The fuel composition according to Claim 22, wherein the hydrocarbyl-terminated poly(oxyalkylene) monool of component (c) has an average molecular weight of about 900 to 1500.

38. The fuel composition according to Claim 22, wherein the oxyalkylene group of the hydrocarbyl-terminated poly(oxyalkylene) monool of component (c) is a C_3 to C_4 oxyalkylene group.

39. The fuel composition according to Claim 38, wherein the oxyalkylene group of the hydrocarbyl-terminated poly(oxyalkylene) monool of component (c) is a C_3 oxypropylene group.

40. The fuel composition according to Claim 38, wherein the oxyalkylene group of the hydrocarbyl-terminated poly(oxyalkylene) monool of component (c) is a C_4 oxybutylene group.

41. The fuel composition according to Claim 22, wherein the hydrocarbyl group of the hydrocarbyl-terminated poly(oxyalkylene) monool of component (c) is a C_7 to C_{30} alkylphenyl group.

42. The fuel composition according to Claim 22, wherein component (a) is a polyisobutenyl amine, wherein the amine moiety is derived from ethylene diamine or diethylene triamine, component (b) is polyisobutene, and component (c) is a C_7 to C_{30} alkylphenyl-terminated poly(oxybutylene) monool.

43. A fuel concentrate comprising an inert stable oleophilic organic solvent boiling in the range of from about 150°F to 400°F and from about 10 to 90 weight percent of an additive composition comprising:

(a) a fuel-soluble aliphatic hydrocarbyl-substituted amine having at least one basic nitrogen atom wherein the hydrocarbyl group has a number average molecular weight of about 700 to 3,000;

(b) a polyolefin polymer of a C_2 to C_6 monoolefin, wherein the polymer has a number average molecular weight of about 350 to 3,000; and

(c) a hydrocarbyl-terminated poly(oxyalkylene) monool having an average molecular weight of about 500 to about 5,000, wherein the oxyalkylene group is a C_2 to C_5 oxyalkylene group and the hydrocarbyl group is a C_1 to C_{30} hydrocarbyl group.

44. The fuel concentrate according to Claim 43, wherein the hydrocarbyl substituent on the aliphatic amine of component (a) has a number average molecular weight of about 750 to 2,200.

45. The fuel concentrate according to Claim 44, wherein the hydrocarbyl substituent on the aliphatic amine of component (a) has a number average molecular weight of about 900 to 1,500.

46. The fuel concentrate according to Claim 43, wherein the aliphatic amine of component (a) is a branched chain hydrocarbyl-substituted amine.

47. The fuel concentrate according to Claim 46, wherein the aliphatic amine of component (a) is a polyisobutenyl amine.

48. The fuel concentrate according to Claim 46, wherein the amine moiety of the aliphatic amine is derived from a polyamine having from 2 to 12 amine nitrogen atoms and from 2 to 40 carbon atoms.

49. The fuel concentrate according to Claim 48, wherein the polyamine is a polyalkylene polyamine having 2 to 12 amine nitrogen atoms and 2 to 24 carbon atoms.

50. The fuel concentrate according to Claim 49, wherein the polyalkylene polyamine is selected from the group consisting of ethylene diamine, diethylene triamine, triethylene tetramine and tetraethylene pentamine.

51. The fuel concentrate according to Claim 50, wherein the polyalkylene polyamine is ethylene diamine or diethylene triamine.

52. The fuel concentrate according to Claim 51, wherein the aliphatic amine of component (a) is a polyisobutenyl ethylene diamine.

53. The fuel concentrate according to Claim 43, wherein the polyolefin polymer of component (b) is a polymer of a C_2 to C_4 monoolefin.

54. The fuel concentrate according to Claim 53, wherein the polyolefin polymer of component (b) is polypropylene or polybutene.

55. The fuel concentrate according to Claim 54, wherein the polyolefin polymer of component (b) is polyisobutene.

56. The fuel concentrate according to Claim 43, wherein the polyolefin polymer of component (b) has a number average molecular weight of about 350 to 1500.

57. The fuel concentrate according to Claim 56, wherein the polyolefin polymer of component (b) has a number average molecular weight of about 350 to 500.

58. The fuel concentrate according to Claim 43, wherein the hydrocarbyl-terminated poly(oxyalkylene) monool of component (c) has an average molecular weight of about 900 to 1500.

59. The fuel concentrate according to Claim 43, wherein the oxyalkylene group of the hydrocarbyl-terminated poly(oxyalkylene) monool of component (c) is a C_3 to C_4 oxyalkylene group.

60. The fuel concentrate according to Claim 59, wherein the oxyalkylene group of the hydrocarbyl-terminated poly(oxyalkylene) monool of component (c) is a C_3 oxypropylene group.

61. The fuel concentrate according to Claim 59, wherein the oxyalkylene group of the hydrocarbyl-terminated poly(oxyalkylene) monool of component (c) is a C_4 oxybutylene group.

62. The fuel concentrate according to Claim 43, wherein the hydrocarbyl group of the hydrocarbyl-terminated poly(oxyalkylene) monool of component (c) is a C_7 to C_{30} alkylphenyl group.

63. The fuel concentrate according to Claim 43, wherein component (a) is a polyisobutenyl amine, wherein the amine moiety is derived from ethylene diamine or diethylene triamine, component (b) is polyisobutene, and component (c) is a C_7 to C_{30} alkylphenyl-terminated poly(oxybutylene) monool.

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US95/04981

A. CLASSIFICATION OF SUBJECT MATTER
IPC(6) : C10L 1/18, 1/22
US CL :044/412, 432
According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
U.S. : 044/412, 432

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US,A, 5,006,130 (Aiello et al) 09 April 1991, see Abstract	1-63
A	US,A, 4,464,182 (Tack et al) 07 August 1984, see entire document.	1-63
A	US,A, 4,357,148 (Graiff) 02 November 1982, see claims 1-5	1-63
A	US,A, 4,125,382 (O'Brien et al) 14 November 1978, see abstract, see claim 1.	1-63
A	US,A, 3,438,757 (Honnen et al) 15 April 1969, see entire document.	1-63

☐ Further documents are listed in the continuation of Box C. ☐ See patent family annex.

*	Special categories of cited documents:	"T"	later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"A"	document defining the general state of the art which is not considered to be of particular relevance	"X"	document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
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Date of the actual completion of the international search	Date of mailing of the international search report
13 JUNE 1995	14 JUL 1995
Name and mailing address of the ISA/US Commissioner of Patents and Trademarks Box PCT Washington, D.C. 20231 Facsimile No. (703) 305-3230	Authorized officer JACQUELINE V. HOWARD Telephone No. (703) 308-2514

Form PCT/ISA/210 (second sheet)(July 1992)*